TITLE OF THE INVENTION

OPTICAL COMMUNICATION SYSTEM AND METHOD OF ASSIGNING SIGNAL
CHANNELS

5   ## BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of assigning
signal channels which assigns a signal channel to be added
to every node, which is arranged at a predetermined position

10   on an optical transmission line and adds signals of a
predetermined channel to the optical transmission line, and
an optical communication system including nodes each adding
signals of a channel assigned by this assigning method to
the optical transmission line.

15   ### Related Background Art

In a wavelength division multiplexing (WDM:
Wavelength Division Multiplexing) optical communication
system for transmitting signals having wavelengths
different from each other, at a node provided on an optical

20   transmission line, there is a case where signals of a
predetermined wavelength (predetermined channel) is
dropped (received by the node and is not transmitted to a
downstream optical transmission line), or signals of a
predetermined channel is added (transmitted from the node

25   and is not transmitted to a downstream optical transmission
line). An optical communication system for adding signals

of a predetermined channel to an optical transmission line

from a node is disclosed in, for example, Japanese Patent

Laid-Open No.13356/1998, No.172449/1997, and the like.

SUMMARY OF THE INVENTION

5   The present inventors reviewed the above prior art

and consequently found problems as set forth below. Namely,

in general, dispersion of an optical transmission line has

wavelength dependency, and according to an added signal

wavelength, there is a case where accumulated-dispersion

10   at a receiving end reaches such a level as to have a bad

influence on transmission characteristics. Particularly,

due to a high-speed transmission, a difference between

wavelengths (difference between channels) in the influence

of accumulated-dispersion becomes more remarkable. If a

15   dispersion compensator for compensating the dispersion is

individually introduced with respect to added signals in

order to compensate this, manufacturing cost of the optical

communication system is increased and enlargement of an

apparatus is caused.

20   The present invention has been made to solve the above

problems, and has an object to provide an optical

communication system including a structure which can

suppress the manufacturing cost to be low while suppressing

deterioration of transmission characteristics of signals

25   added to an optical transmission line from each node, and

a signal channel assigning method.

An optical communication system according to the present invention comprises an optical transmission line disposed between a transmitting end and a receiving end, for transmitting signals of plural channels, and one or more

5   nodes each arranged at a predetermined position of the optical transmission line and adding signals of a predetermined channel to the optical transmission line. A signal channel assigning method according to the present invention assigns optimum signal channels to one or more

10   nodes respectively in advance or dynamically. Specifically, to each of the nodes, among signal channels which can be added to the optical transmission line, a signal channel at which the absolute value of accumulated-dispersion from the node itself to the receiving end becomes smallest is

15   assigned in advance or dynamically. In particular, in the case where a plurality of nodes are arranged on the optical transmission line, it is preferable that wavelength dependency of accumulated-dispersion up to the receiving end is calculated for each of the nodes in advance, and the

20   optimum signal channels are assigned in advance or dynamically to the nodes in descending order of the absolute value of the accumulated-dispersion.

As described above, for each of the nodes disposed on the optical transmission line in the optical communication

25   system and assigned with the optimum signal channel, it becomes possible to add signals by which the absolute value

of the accumulated-dispersion from the node to the receiving
end becomes smallest among signal channels which can be added
to the optical transmission line, to the optical transmission
line. Thus, in accordance with the optical communication

5   system and the signal channel assigning method, the
transmission characteristics of the signals added at each
of the nodes are excellent as compared with a case where
any one of other signal channels is selected.

Incidentally, in the optical transmission line in

10   which a signal transmission path is fixed, although a desired
optical communication system is realized by providing signal
sources (light sources) outputting signals of previously
assigned channels to corresponding nodes respectively, it
is also conceivable that a transmission path varies for every

15   signal channel. In the latter case, it is necessary that
a tunable light source, a plurality of light sources
outputting wavelengths different from each other, or a single
light source simultaneously outputting signals of plural
channels is prepared at each of the nodes in advance, and

20   an optimum signal channel is assigned to each of the nodes
dynamically.

Like this, in the case where the optimum signal channel
is assigned to each of the nodes dynamically, each of the
nodes preferably includes a node control system specifying

25   signal channels which can be added to the optical
transmission line, and assigning a signal channel at which

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the absolute value of the accumulated-dispersion from the associated node to the receiving end becomes smallest to the node, among these specified signal channels.

On the other hand, in the case where the optimum signal channel is assigned to each of the nodes dynamically in predetermined order, the optical communication system preferably includes a centralized control system calculating wavelength dependency of accumulated-dispersion up to the receiving end for each of the nodes, and assigning optimum signal channels to the nodes in descending order of the absolute value of the accumulated-dispersion. Incidentally, in this centralized control system, as a method of assigning signal channels according to the present invention, signal channels which can be added to the optical transmission line are specified for the respective nodes selected in the predetermined order, and among these specified signal channels, a signal channel at which the absolute value of the accumulated-dispersion from the selected node to the receiving end becomes smallest is assigned to the selected node.

Besides, the optical communication system according to the present invention may include a dispersion compensator provided at predetermined position on the optical transmission line. When the dispersion compensator is provided, although the power of signals added to the node

relatively far from the receiving end is reduced to some
degree before the signals reach the receiving end, since
the absolute value of the accumulated-dispersion up to the
receiving end is small, a sufficient reception margin can
be secured. On the contrary, since signals added to the
node relatively close to the receiving end has sufficient
power even at the point of time when the signals reach the
receiving end, even if the absolute value of the
accumulated-dispersion up to the receiving end is relatively
large, a sufficient reception margin can be secured.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing a structure of a first
embodiment of an optical communication system according to
the present invention;

Fig. 2 is a flowchart for explaining a first embodiment
of a method of assigning signal channels according to the
present invention;

Fig. 3 is a graph for supplementally explaining the
signal channel assigning method according to the first
embodiment;

Figs. 4A and 4B are views showing another structural
examples of respective nodes;

Fig. 5 is a view showing a structure of a second
embodiment of an optical communication system according to
the present invention;

Fig. 6 is a flowchart for explaining a second

embodiment of a method of assigning signal channels according to the present invention;

Fig. 7 is a graph for supplementally explaining the signal channel assigning method according to the second embodiment;

Fig. 8 is a view showing another structure of the optical communication system according to the second embodiment shown in Fig. 6;

Fig. 9 is a view showing a structure of a third embodiment of an optical communication system according to the present invention;

Fig. 10 is a graph for supplementally explaining the signal channel assigning method in the optical communication system according to the third embodiment; and

Fig. 11 is a graph showing the relation between bit error rate and necessary reception power for a case where the absolute value of accumulated-dispersion is small and for a case where it is large.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Respective embodiments of an optical communication system and a signal channel assigning method according to the present invention will be hereinafter described with reference to Figs. 1-3, 4A, 4B, and 5-11. Incidentally, in the explanation of the drawings, the same elements are designated by the same characters and duplicate explanation is omitted.

(First embodiment of an optical communication system and a method of assigning signal channels)

Fig. 1 is a view showing a structure of a first embodiment of an optical communication system according to the present invention, and in the structure shown in Fig. 1, a transmission path of signal is fixed, and an optimum signal channel is previously assigned to each of nodes A and B which add signals of predetermined channels to an optical transmission line.

In an optical communication system 1 according to the first embodiment, the nodes A and B are arranged on the optical transmission line provided between a transmitter 10 and a receiver 20. The node A includes an ADM (Add Drop Multiplexer) 31 and a light source 11 for transmitting signals of the previously assigned optimum channel through the ADM 31 to the optical transmission line. Similarly, the node B includes an ADM 32 and a light source 12 for transmitting signals of the previously assigned optimum channel through the ADM 32 to the optical transmission line. An optical fiber 51 is provided between the transmitter 10 and the ADM 31, an optical fiber 52 is provided between the ADM 31 and the ADM 32, an optical fiber 53 is provided between the ADM 32 and the receiver 20, and the optical transmission line from the transmitter 10 to the receiver 20 is constituted by these optical fibers 51 to 53. Besides, an optical fiber 61 is provided between the light source 11 and the ADM 31,

and an optical fiber 62 is provided between the light source 12 and the ADM 32.

In the optical communication system 1 according to the first embodiment, the signals outputted from the

5   transmitter 10 propagate through the optical fibers 51 to 53 in sequence and reach the receiver 20. Alternatively, there is also a case where the signal outputted from the transmitter 10 is dropped by the ADM 31 or the ADM 32, and is received by a receiver (not shown). At the node A, the

10   signals outputted from the light source 11 propagate through the optical fiber 61 and reach the ADM 31, and they are sent from the ADM 31 to the optical fiber 52. Then, the signals from the light source 11 propagate through the optical fibers 52 and 53 in sequence and reach the receiver 20. On the

15   other hand, at the node B, the signals outputted from the light source 12 propagate through the optical fiber 62 and reach the ADM 32, and they are sent from the ADM 32 to the optical fiber 53. Then, the signals from the light source 12 propagate through the optical fiber 53 and reach the

20   receiver 20.

As each of the optical fibers 51 to 53, a single mode optical fiber having a zero dispersion wavelength near a wavelength of 1.3 µm, a dispersion compensating optical fiber for compensating chromatic dispersion of the single-mode

25   optical fiber at a wavelength of 1.55 µm band, a dispersion-shifted optical fiber having a zero dispersion

wavelength near a wavelength of 1.55 μm, or the like can be applied. From the viewpoint of enabling these silica-based optical fibers to transmit at the lowest loss and the viewpoint of easiness of loss compensation by an

5 optical amplifier, it is preferable that each of the transmitter 10 and the light sources 11 and 12 outputs signals having a wavelength of 1.55 μm band.

Incidentally, in Fig. 1, point X indicates a position of an output end in the transmitter 10, point A indicates

10 a position of an output end in the ADM 31, and point B indicates a position of an output end in the ADM 32. Figs. 2 and 3 are a flowchart and a graph for explaining a signal channel assigning method (first embodiment of a signal channel assigning method according to the present invention) in the

15 optical communication system 1 according to the first embodiment. In particular, in the graph shown in Fig. 3, a signal wavelength band is $\lambda_1 - \lambda_2$, a curve G100 indicates wavelength dependency of accumulated-dispersion from the point X to the receiver 20, a curve G110 indicates wavelength

20 dependency of accumulated-dispersion from the point A to the receiver 20, and a curve G120 indicates wavelength dependency of accumulated-dispersion from the point B to the receiver 20.

As shown in Fig. 3, in the optical communication system

25 1, optical fibers having suitable chromatic dispersion characteristics in the signal wavelength band ($\lambda_1 - \lambda_2$) are

applied as the optical fibers 51 to 53 constituting the optical transmission line. By this, the absolute value of accumulated-dispersion of the optical transmission line from the transmitter 10 to the receiver 20 becomes small,

5   and deterioration of transmission characteristics of signals from the transmitter 10 to the receiver 20 is also effectively suppressed. However, the absolute value of accumulated-dispersion of the optical transmission line from the light source 11 through the ADM 31 to the receiver

10   20 is not necessarily small, and the absolute value of accumulated-dispersion of the optical transmission line from the light source 12 through the ADM 32 to the receiver 20 is also not necessarily small.

Then, in this first embodiment, a channel of signals

15   outputted from the light source 11 and added through the ADM 31 to the optical transmission line is assigned to the node A in advance, and a channel of signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line is assigned to the node B in advance, in

20   accordance with the flowchart shown in Fig. 2.

First, in the signal channel assignment for node A, as channel candidates of signals outputted from the light source 11 and added through the ADM 31 to the optical transmission line, it is first necessary to specify signal

25   channels which can be added by the ADM 31 (step ST1). Subsequently, accumulated-dispersion from the point A to

the receiver 20 for each of the specified candidates is calculated (step ST2), and a signal channel (wavelength λ_A) at which the absolute value of the calculated accumulated-dispersion is smallest is selected as the signal

5   channel to be added from the node A (step ST3). For example, as shown in Fig. 3, in the signal wavelength band, if both the accumulated-dispersion and dispersion slope from the point A to the receiver 20 are positive, the channel of the shortest wavelength among the channels which can be added

10   by the ADM 31 is assigned as the channel (wavelength λ_A) of the signals outputted from the light source 11 and added through the ADM 31 to the optical transmission line. If the signals of the lower limit wavelength λ_1 of the signal wavelength band can be added through the ADM 31, $\lambda_A = \lambda_1$.

15   Similarly, in the signal channel assignment for the node B, first, as channel candidates of signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line, signal channels which can be added through the ADM 32 are specified (step ST). Then,

20   accumulated-dispersion from the point B to the receiver 20 is calculated for each of the specified candidates (step ST2), and a signal channel (wavelength λ_B) at which the absolute value of the calculated accumulated-dispersion is smallest is selected as the signal channel to be added from

25   the node B (step ST3). For example, as shown in Fig. 3, in the signal wavelength band, if the accumulated-dispersion

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from the point B to the receiver 20 is negative and the dispersion slope is positive, the signal channel of the longest wavelength among the channels which can be added by the ADM 32 is assigned as the channel (wavelength λ_B) of the signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line. If the signals of the upper limit wavelength λ_2 of the signal wavelength band can be added by the ADM 32, $\lambda_B = \lambda_2$.

The assignment of the optimum signal channel as described above is performed for all nodes (step ST4). In the foregoing signal channel assignment, to each of the nodes on the optical transmission line, among the signal channels which can be added, the signal channel at which the absolute value of the accumulated-dispersion from the node itself to the receiver 20 is smallest is assigned in advance as the channel of the signals outputted from the light source and added from the ADM to the optical transmission line. By this, transmission characteristics of the signals outputted from the respective light sources 11 and 12 in the respective nodes A and B and received by the receiver 20 are excellent as compared with the case where other signal channels are selected.

Incidentally, with respect to this first embodiment, in the above signal channel assignment, although it is assumed that the transmission path of signal is fixed, it is also conceivable that the transmission path varies for

each signal channel. In the latter case, at each of the

nodes, it is necessary to assign the optimum signal channel

dynamically. Figs. 4A and 4B show structures for assigning

the optimum signal channel dynamically to each node.

5   Incidentally, although these drawings show only the

structure of the node A, the node B is also provided with

the same structure as the node A.

In the first structure as shown in Fig. 4A, the node

A includes an ADM 31, a plurality of light sources 110 for

10   outputting signals having wavelengths different from each

other, a multiplexer 111 for connecting the ADM 31 to the

plurality of light sources 110 one-to-many, and a node

control system 112 for selecting an optimum signal channel

for the node A.   As shown in Fig. 2, from signals transmitted

15   through the optical fiber 51 and having reached the ADM 31,

the node control system 112 specifies signal channels which

can be added from the node A (step ST1), and calculates the

absolute value of accumulated-dispersion from the node A

to the receiver 20 for these specified signal channels (step

20   ST2). Subsequently, the node control system 112 selects

a signal channel at which the absolute value of the calculated

accumulated-dispersion is smallest (step ST3), and controls

the driving of the light source to output signals of a

wavelength corresponding to the selected signal channel.

25   Incidentally, the foregoing assignment operation is the same

with the node B.

On the other hand, in the second structure as shown in Fig. 4B, the node A includes an ADM 31, a tunable light source 113, and a node control system 112 for selecting an optimum signal channel for the node A. Also in this second

5 structure, the node control system 112 performs the assignment operation as described above, and controls the tunable light source 113 to output signals of a wavelength corresponding to the selected signal channel (the same applies to the node B). Incidentally, the light source 113

10 may be a single light source for simultaneously outputting signals (having wavelengths different from each other) of plural channels.

As described above, by arranging the nodes having the structures as shown in Figs. 4A and 4B at predetermined

15 positions on the optical transmission line respectively, the optical communication system for assigning the optimum signal channel dynamically at each of the nodes can be realized.

(Second embodiment of an optical communication system and

20 a signal channel assigning method)

A second embodiment of an optical communication system and a signal channel assigning method according to the present invention will next be described.

Fig. 5 is a view showing a structure of the second

25 embodiment of the optical communication system according to the present invention, and also in the structure shown

in Fig. 5, a transmission path of signal is fixed, and an optimum signal channel is previously assigned to each of nodes A, B and C which add signals of predetermined channels to an optical transmission line.

5   In an optical communication system 2 according to the second embodiment, the nodes A, B and C are arranged on the optical transmission line provided between a transmitter 10 and a receiver 20. The node A includes an ADM 31 and a light source 11 for transmitting signals of the previously

10   assigned optimum channel through the ADM 31 to the optical transmission line. The node B includes an ADM 32 and a light source 12 for transmitting signals of the previously assigned optimum channel through the ADM 32 to the optical transmission line. The node C includes an ADM 33 and a light

15   source 13 for transmitting signals of the previously assigned optimum channel through the ADM 33 to the optical transmission line. An optical fiber 51 is provided between the transmitter 10 and the ADM 31, an optical fiber 52 is provided between the ADM 31 and the ADM 32, an optical fiber

20   53 is provided between the ADM 32 and the ADM 33, an optical fiber 54 is provided between the ADM 33 and the receiver 20, and the optical transmission path from the transmitter 10 to the receiver 20 is constituted by these optical fibers 51 to 54. Besides, an optical fiber 61 is provided between

25   the light source 11 and the ADM 31, an optical fiber 62 is provided between the light source 12 and the ADM 32, and

an optical fiber 63 is provided between the light source
13 and the ADM 33.

In the optical communication system 2 according to
this second embodiment, signals outputted from the
transmitter 10 propagate through the optical fibers 51 to
54 in sequence and reach the receiver 20. Alternatively,
there is also a case where the signal outputted from the
transmitter 10 is dropped by any one of the ADMs 31 to 33,
and is received by a receiver (not shown). At the node A,
signals outputted from the light source 11 propagate through
the optical fiber 61 and reach the ADM 31, and they are sent
from the ADM 31 to the optical fiber 52. Then, the signals
from the light source 11 propagate through the optical fibers
52 to 54 in sequence and reach the receiver 20. On the other
hand, at the node B, signals outputted from the light source
12 propagate through the optical fiber 62 and reach the ADM
32, and they are sent from the ADM 32 to the optical fiber
53. Then, the signals from the light source 12 propagate
through the optical fibers 53 and 54 in sequence and reach
the receiver 20. Further, at the node C, signals outputted
from the light source 13 propagate through the optical fiber
63 and reach the ADM 33, and they are sent from the ADM 33
to the optical fiber 54. Then, the signals from the light
source 13 propagate through the optical fiber 54 and reach
the receiver 20.

As each of the optical fibers 51 to 54, a single mode

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optical fiber having a zero dispersion wavelength near a wavelength of 1.3 μm, a dispersion compensating optical fiber for compensating chromatic dispersion of the single-mode optical fiber at a wavelength 1.55 μm band, a

5   dispersion-shifted optical fiber having a zero dispersion wavelength near a wavelength of 1.55 μm, or the like can be applied. From the viewpoint of enabling these silica-based optical fibers to transmit at the lowest loss and the viewpoint of easiness of loss compensation by an

10   optical amplifier, it is preferable that each of the transmitter 10 and the light sources 11 to 13 outputs signals having a wavelength of 1.55 μm band.

Incidentally, in Fig. 5, point A indicates a position of an output end in the ADM 31, point B indicates a position

15   of an output end in the ADM 32, and point C indicates a position of an output end in the ADM 33. Figs. 6 and 7 are a flowchart and a graph for explaining a signal channel assigning method (second embodiment of a signal channel assigning method according to the present invention) in the optical

20   communication system 2 according to the second embodiment. In particular, in the graph shown in Fig. 7, a signal wavelength band of usable signal channels is (wavelength λ_1 to λ_2), a curve G210 indicates wavelength dependency of accumulated-dispersion from the point A to the receiver 20,

25   a curve G220 indicates wavelength dependency of accumulated-dispersion from the point B to the receiver 20,

and a curve G230 indicates wavelength dependency of accumulated-dispersion from the point C to the receiver 20.

As shown in Fig. 7, in the optical communication system 2, in the signal wavelength band (wavelength λ_1 to λ_2), optical fibers having suitable chromatic dispersion characteristics are applied as the optical fibers 51 to 54 constituting the optical transmission line from the transmitter 10 to the receiver 20. Thereby, the absolute value of accumulated-dispersion from the transmitter 10 to the receiver 20 becomes small, and deterioration of transmission characteristics of signals from the transmitter 10 to the receiver 20 is also effectively suppressed. However, the absolute value of accumulated-dispersion in the optical transmission line from the light source 11 through the ADM 31 to the receiver 20 is not necessarily small, the absolute value of accumulated-dispersion in the optical transmission line from the light source 12 through the ADM 32 to the receiver 20 is also not necessarily small, and the absolute value of accumulated-dispersion in the optical transmission line from the light source 13 through the ADM 33 to the receiver 20 is also not necessarily small.

Then, in this second embodiment, a channel of signals outputted from the light source 11 and added through the ADM 31 to the optical transmission line is previously assigned to the node A, a channel of signals outputted from

the light source 12 and added through the ADM 32 to the optical

transmission line is previously assigned to the node B, and

a channel of signals outputted from the light source 13 and

added through the ADM 33 to the optical transmission line

5   is previously assigned to the node C, in accordance with

the flowchart shown in Fig. 6.

First, prior to the signal channel assignment for the

nodes A to C, wavelength dependency of each

accumulated-dispersion from each of the point A, the point

10   B and point C to the receiver 20 is calculated (steps ST5,

ST6). On the basis of the wavelength dependency of each

calculated accumulated-dispersion, the signal channel

assignment is performed to the nodes in descending order

of the absolute value of the accumulated-dispersion up to

15   the receiver 20 (step ST7).

In the following explanation, it is assumed that as

shown in Fig. 7, in the signal wavelength band, both the

accumulated-dispersion and dispersion slope from each of

the point A, the point B and the point C to the receiver

20   20 are positive, the absolute value of the

accumulated-dispersion from the point A to the receiver 20

is largest, and the absolute value of the

accumulated-dispersion from the point B to the receiver 20

and the absolute value of the accumulated-dispersion from

25   the point C to the receiver 20 become small in this order.

In this case, the signal channel assignment is performed

in order of the node A, the node B and the node C.

In the signal channel assignment for the node A, as channel candidates of signals outputted from the light source 11 and added through the ADM 31 to the optical transmission line, signal channels which can be added by the ADM 31 are first specified (step ST8). Subsequently, from these specified candidates, a signal channel (wavelength λ_A) at which the absolute value of the accumulated-dispersion from the point A to the receiver 20 is smallest is selected as the signal channel to be added from the node A (step ST9). For example, as shown in Fig. 7, in the signal wavelength band, if both the accumulated-dispersion and the dispersion slope from the point A to the receiver 20 are positive, the channel of the shortest wavelength among the channels which can be added by the ADM 31 is assigned as the channel (wavelength λ_A) of the signal outputted from the light source 11 and added through the ADM 31 to the optical transmission line. If the signals of the lower limit wavelength λ_1 in the signal wavelength band can be added through the ADM 31, $\lambda_A = \lambda_1$.

Next, in the signal channel assignment for the node B, as channel candidates of signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line, channels which can be add through the ADM 32 are specified (step ST8). From the specified candidates, a channel (wavelength λ_B) at which the absolute

value of the accumulated-dispersion from the point B to the receiver 20 is smallest is selected as the signal channel to be added from the node B (step ST9). Incidentally, since the wavelength λ_A is already assigned to the node A as the signal channel added at the point A, it can not be assigned to the node B as the signal channel to be added at the point B.

Finally, also in the signal channel assignment for the node C, as channel candidates of signals outputted from the light source 13 and added through the ADM 33 to the optical transmission line, channels which can be added by the ADM 33 are first specified (step ST8). Then, a channel (wavelength λ_c) at which the absolute value of the accumulated-dispersion from the point C to the receiver 20 is smallest is selected as the signal channel to be added from the node C (step ST9). Also in the signal channel assignment for the node C, since both the wavelengths λ_A and λ_B are already assigned to the node A and the node B as the signal channels added at the point A and the point B, they can not be assigned to the node C as the signal channel to be added at the point C.

The assignment of the optimum signal channel as described above is performed to all nodes (step ST10). In the foregoing signal channel assignment, the wavelength dependency of each accumulated-dispersion from each of the nodes on the optical transmission line to the receiver 20

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is calculated in advance, and on the basis of the wavelength
dependency of each calculated accumulated-dispersion, the
assignment of the optimum signal channel is performed to
the node in descending order of the absolute value of the
5   accumulated-dispersion up to the receiver 20.   Thereby, the
transmission characteristics of the signals outputted from
each of the light sources 11 to 13 in the respective nodes
A to C and reaching the receiver 20 are excellent as compared
with the case where a combination of other signal channels
10   is selected.

Incidentally, with respect to this second embodiment,
in the above signal channel assignment, although it is
assumed that the transmission path of signal is fixed, it
is also conceivable that the transmission path varies for
15   each signal channel.   In the latter case, it is necessary
to assign the optimum signal channel dynamically to the
respective nodes, and similarly to the foregoing first
embodiment, when the structure of each of the nodes A to
C is made the structure shown in Figs. 4A and 4B, dynamic
20   assignment of the optimum signal channel can be performed
for each node.   Besides, the dynamic assignment of signal
channel in the second embodiment can be performed
centralizedly.   Fig. 8 is a view showing a structure for
centralizedly performing the dynamic assignment of the
25   optimum signal channel to the respective nodes in the optical
communication system 2 according to the second embodiment.

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In the optical communication system 2 shown in Fig. 8, a node A includes, as shown in Fig. 4B, an ADM 31 and a tunable light source 113 (as shown in Fig. 4A, a plurality of light sources outputting signals having wavelengths

5   different from each other may be included). A node B includes, as shown in Fig. 4B, an ADM 32 and a tunable light source 114 (as shown in Fig. 4A, a plurality of light sources outputting signals having wavelengths different from each other may be included). Further, a node C includes, as shown

10   in Fig. 4B, an ADM 33 and a tunable light source 115 (as shown in Fig. 4A, a plurality of light sources outputting signals having wavelengths different from each other may be included). The optical communication system 2 includes a centralized control system 116 for dynamically assigning

15   optimum signal channels to these nodes A to C. As shown in Fig. 7, this centralized control system 116 also determines assignment order for signal channels as to the nodes A to C (steps ST5 to ST7), and assigns the optimum signal channels to the respective nodes in the determined

20   order (steps ST8 to ST10).

(Third embodiment of an optical communication system)

Next, a third embodiment of an optical communication system according to the present invention will be described. Fig. 9 is a view showing a structure according to the third

25   embodiment of the optical communication system according to the present invention. Incidentally, in an optical

communication system 3 according to this third embodiment, both the signal channel assigning methods of the first and the second embodiments may be carried out.

In the optical communication system 3 according to the third embodiment, a node A, a node B, and a dispersion compensator 40 are arranged on an optical transmission line provided between a transmitter 10 and a receiver 20. The node A includes an ADM 31 and a light source 11 for sending signals of a previously assigned optimum channel through the ADM 31 to the optical transmission line. Similarly, the node B includes an ADM 32 and a light source 12 for sending signals of a previously assigned optimum channel through the ADM 32 to the optical transmission line. An optical fiber 51 is provided between the transmitter 10 and the ADM 31, an optical fiber 52 is provided between the ADM 31 and the ADM 32, an optical fiber 53 and the dispersion compensator 40 are provided between the ADM 32 and the receiver 20, and the optical transmission line from the transmitter 10 to the receiver 20 is constituted by these optical fibers 51 to 53. Further, an optical fiber 61 is provided between the light source 11 and the ADM 31, and an optical fiber 62 is provided between the light source 12 and the ADM 32.

In the optical communication system 3 according to the third embodiment, signals outputted from the transmitter 10 propagate through the optical fibers 51 to 53 and the dispersion compensator 40 in sequence and reach the receiver

20. Alternatively, there is also a case where the signals
outputted from the transmitter 10 are dropped by the ADM
31 or the ADM 32, and are received by a receiver (not shown).
At the node A, signals outputted from the light source 11

5   propagate through the optical fiber 61 and reach the ADM
31, and they are sent from the ADM 31 to the optical fiber
52. Then, the signals from the light source 11 propagate
through the optical fibers 52 and 53 and the dispersion
compensator 40 in sequence and reach the receiver 20. On

10   the other hand, at the node B, signals outputted from the
light source 12 propagate through the optical fiber 62 and
reach the ADM 32, and they are sent from the ADM 32 to the
optical fiber 53. Then, the signals from the light source
12 propagate through the optical fiber 53 and the dispersion

15   compensator 40 in sequence and reach the receiver 20.

As each of the optical fibers 51 to 53, a single mode
optical fiber having a zero dispersion wavelength near a
wavelength of 1.3 μm, a dispersion compensating optical fiber
for compensating chromatic dispersion of the single-mode

20   optical fiber at a wavelength of 1.55 μm band, a
dispersion-shifted optical fiber having a zero dispersion
wavelength near a wavelength of 1.55 μm, or the like can
be applied. From the viewpoint of enabling these
silica-based optical fibers to transmit at the lowest loss

25   and the viewpoint of easiness of loss compensation by an
optical amplifier, it is preferable that each of the

transmitter 10 and the light sources 11 and 12 outputs signals having a wavelength of 1.55 μm band.

Incidentally, in Fig. 9, point X indicates a position of an output end in the transmitter 10, point A indicates a position of an output end in the ADM 31, and point B indicates a position of an output end in the ADM 32. Fig. 10 is a view for supplementally explaining a signal channel assigning method in the optical communication system 3 according to the third embodiment. In the graph of Fig. 10, a wavelength band of usable signal channels is λ_1 to λ_2, a graph G300 indicates wavelength dependency of accumulated-dispersion from the point X to the receiver 20, a graph G310 indicates wavelength dependency of accumulated-dispersion from the point A to the receiver 20, and a graph G320 indicates wavelength dependency of accumulated-dispersion from the point B to the receiver 20.

As shown in Fig. 10, in the optical communication system 3, in the signal wavelength band (wavelength λ_1 to λ_2), optical fibers having suitable chromatic dispersion characteristics are applied as the optical fibers 51 to 53 constituting the optical transmission line and the dispersion compensator 40. Thereby, the absolute value of accumulated-dispersion in the optical transmission line from the transmitter 10 to the receiver 20 becomes small, and deterioration of transmission characteristics of signals from the transmitter 10 to the receiver 20 is also

effectively suppressed. However, the absolute value of accumulated-dispersion in the optical transmission line from the light source 11 through the ADM 31 to the receiver 20 is not necessarily small, and the absolute value of

5   accumulated-dispersion in the optical transmission line from the light source 12 through the ADM 32 to the receiver 20 is also not necessarily small.

Then, in this third embodiment, a channel of signals outputted from the light source 11 and added through the

10   ADM 31 to the optical transmission line is assigned to the node A, and a channel of signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line is assigned to the node B, as described below. Incidentally, in the following explanation, in

15   accordance with the signal channel assigning method (Fig. 6) according to the second embodiment, an operation in which optimum signal channels are assigned to the respective nodes A and B in advance will be described.

That is, prior to the signal channel assignment for

20   the nodes A and B, wavelength dependency of each accumulated-dispersion from each of the point A and the point B to the receiver 20 is calculated (steps ST5, ST6). On the basis of the calculated wavelength dependency of each calculated accumulated-dispersion, the assignment of the

25   signal channels is performed to the nodes in descending order of the absolute value of the accumulated-dispersion up to

the receiver 20 (step ST7). In the following explanation, it is assumed that as shown in Fig. 10, in the signal wavelength band, both the accumulated-dispersion and dispersion slope from each of the point A and the point B to the receiver

5   20 are negative, and the absolute value of the accumulated-dispersion from the point A to the receiver 20 is smaller than the absolute value of the accumulated-dispersion from the point B to the receiver 20. In this case, the signal channel assignment is performed

10   in order of the node A and the node B.

First, in the signal channel assignment for the node B, as channel candidates of signals outputted from the light source 12 and added through the ADM 32 to the optical transmission line, signal channels which can be added by

15   the ADM 32 are first specified (step ST8). Subsequently, from these specified candidates, a signal channel (wavelength λ_B) at which the absolute value of the accumulated-dispersion from the point B to the receiver 20 is smallest is selected as the signal channel to be added

20   from the node B (step ST9). For example, as shown in Fig. 10, in the signal wavelength band, if both the accumulated-dispersion and the dispersion slope from the point B to the receiver 20 are negative, the channel of the shortest wavelength among the channels which can be added

25   by the ADM 32 is assigned as the channel (wavelength λ_B) of the signals outputted from the light source 12 and added

through the ADM 32 to the optical transmission line. If the signals of the lower limit wavelength λ_1 of the signal wavelength band can be added through the ADM 32, $\lambda_B = \lambda_1$.

Next, in the signal channel assignment for the node A, as channel candidates of signals outputted from the light source 11 and added through the ADM 31 to the optical transmission line, channels which can be added through the ADM 31 are specified (step ST8). From the specified candidates, a channel (wavelength λ_A) at which the absolute value of the accumulated-dispersion from the point A up to the receiver 20 is smallest is selected as the signal channel to be added from the node A (step ST9). Incidentally, since the wavelength λ_B is already assigned to the node B as the signal channel to be added at the point B, it can not be assigned to the node A as the signal channel to be added at the point A.

The assignment of the optimum signal channel as described above is performed to all nodes (step ST10). In the foregoing signal channel assignment, the wavelength dependency of each accumulated-dispersion from each of the nodes on the optical transmission line to the receiver 20 is calculated in advance, and on the basis of the wavelength dependency of each calculated accumulated-dispersion, the assignment of the optimum signal channel is performed to the node in descending order of the absolute value of the accumulated-dispersion up to the receiver 20. Thereby,

transmission characteristics of the signals outputted from each of the light sources 11 to 12 in the respective nodes A to B and reaching the receiver 20 are excellent as compared with the case where a combination of other signal channels is selected.

In particular, in the third embodiment, since the dispersion compensator 40 is provided between the point B and the receiver 20, not only the absolute value of the accumulated-dispersion from the transmitter 10 (point X) to the receiver 20 is made small, but also the absolute value of the accumulated-dispersion from the light source 11 (point A) to the receiver 20 is made small. Fig. 11 is a graph showing the relation between bit error rate (BER) and necessary receiving power with respect to a case (indicated by a curve G400) where the absolute value of the accumulated-dispersion is small and a case (indicated by a curve G410) where it is large. As shown in this graph, with respect to the signals added at a node relatively far from the receiver 20, since the absolute value of the accumulated-dispersion up to the receiver 20 is small, even if the loss is increased to some degree during transmission through the optical transmission line and the reception signal power at the receiver 20 becomes small, a reception margin is sufficiently secured. On the other hand, with respect to signals added at a node relatively close to the receiver 20, since the reception signal power at the receiver

20 is sufficiently large, even if the absolute value of the accumulated-dispersion up to the receiver 20 is large, a reception margin is sufficiently secured as well.

Incidentally, in the above signal channel assignment, although the description has been made on the case where the transmission path of signal is fixed and the optimum signal channels are assigned to the respective nodes in advance, also in this third embodiment, the optimum signal channels may be dynamically assigned to the respective nodes. In the latter case, in the respective nodes, as shown in Figs. 4A and 4B, the optimum signal channel may be assigned individually by a node control system provided in each of the nodes, or as shown in Fig. 8, the optimum signal channel can also be assigned to each node by a centralized control system.

As described above, in accordance with the present invention, since the signal channel at which the absolute value of the accumulated-dispersion up to the receiving end is smallest among signal channels which can be added, is assigned to every node, it becomes possible to effectively improve the transmission characteristics of the added signals as compared with the case where any one of other channels is selected.